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(54) METHOD FOR OPERATING A WIND ENERGY PLANT

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(57) **ABSTRACT**

The present invention relates to a method for operating a wind turbine with a generator, drivable by a rotor, for supplying electrical power to an electrical load, in particular an electric grid. In order to compensate for fluctuations in the grid as far as possible, the system of the kind initially specified is developed in such a way that the power delivered to the load by the generator is regulated in response to a current outputted to the load.

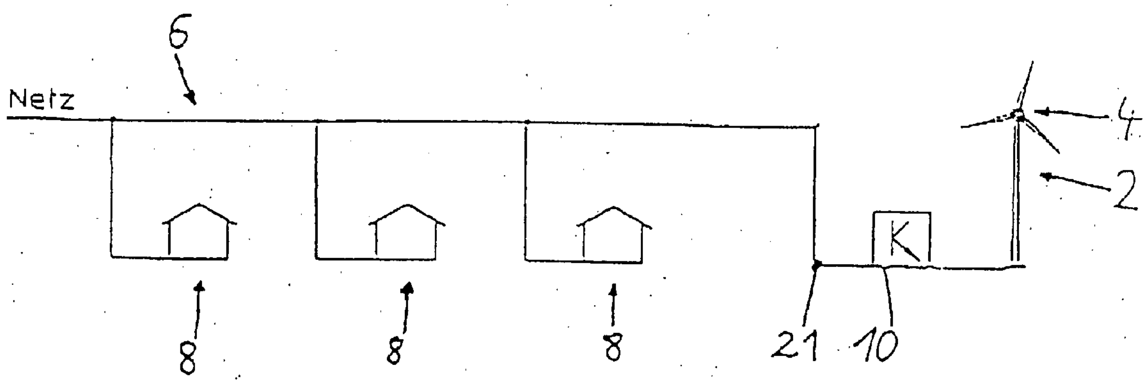


Fig. 1

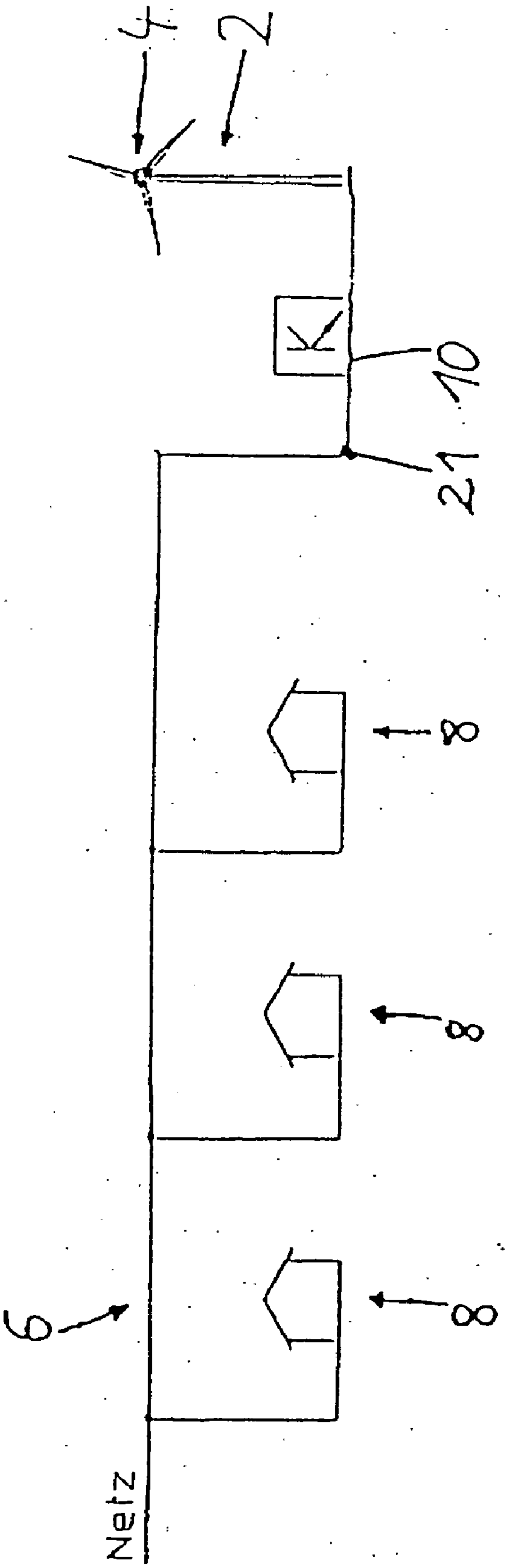


Fig. 2

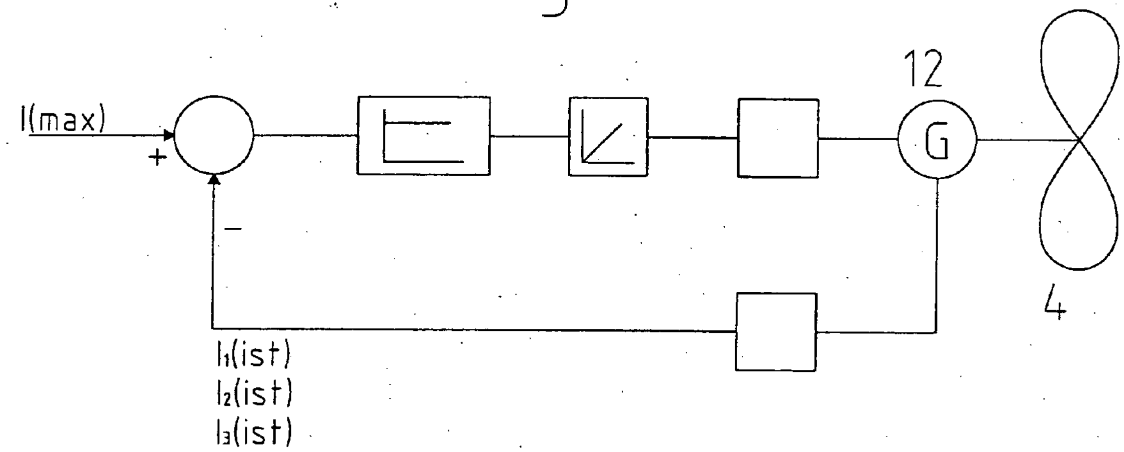
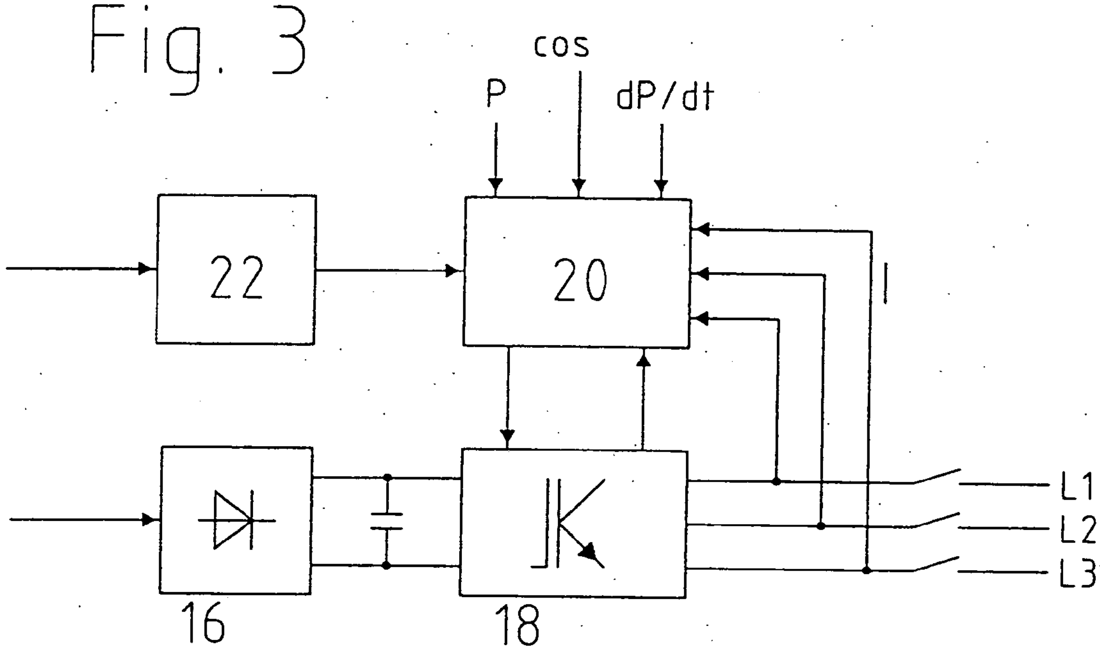


Fig. 3



METHOD FOR OPERATING A WIND ENERGY PLANT

[0001] The present invention relates to a method for operating a wind turbine with an electrical generator, drivable by a rotor, for supplying electrical power to an electrical load, in particular an electric grid.

[0002] The invention further relates to a wind turbine with a rotor and an electrical generator coupled to the rotor for supplying electrical power to an electrical load, in particular an electric grid.

[0003] In known wind turbines for generating electrical energy from wind energy, the generator with the electrical load, often an electric grid, is operated in a grid-parallel mode. In other words, as soon as the wind supply is sufficient, the wind turbine will generate electrical energy and deliver it to the grid.

[0004] However, if a failure occurs in the grid, for example as a result of a short circuit in the grid, wind turbines have hitherto been disconnected from the grid and not reconnected to the grid until normal operating conditions have been restored.

[0005] This means that, following such a grid failure, is no longer possible to provide the rapid support for the grid that is particularly needed when there are large fluctuations in the voltage and/or power that is required.

[0006] The object of the present invention is therefore to provide a control system for one or more wind turbines that compensate as far as possible for fluctuations in the grid.

[0007] This object is achieved with a method of the kind initially specified, in which the power delivered to the load by the generator is regulated in response to a current that is outputted to the load.

[0008] In a device of the kind initially specified, the object is achieved by a control device comprising a current sensor for measuring an electrical current delivered to the load, such that the power delivered by the generator to the load can be controlled in response to the current that is received by the current sensor.

[0009] In this way, the required power can be generated and delivered when there are fluctuations in the power requirements from the grid.

[0010] In order to avoid overload of parts of the wind turbine and/or the grid in the event of a grid failure, for example as a result of a short circuit in the grid, the wind turbine is controlled in such a way that the current delivered to the grid does not exceed a predefined value.

[0011] In a particularly preferred embodiment of the invention, the maximum current level that can be delivered is regulated for each grid phase, in order to support the grid as far as possible, on the one hand, without exposing components to the risk of damage, on the other hand.

[0012] A particularly preferred embodiment is one in which the wind turbine can be operated by an external input that corresponds to the stipulations made by a distant control station. In this way, a power supply company for example can request the wind turbine to deliver the amount of current which is needed at that moment to support the grid.

[0013] Other advantageous embodiments of the invention are described in the subclaims.

[0014] One embodiment of the invention shall now be described in detail with reference to the figures. These show:

[0015] **FIG. 1**. a wind turbine that feeds power to a grid, in a simplified view;

[0016] **FIG. 2**. a control device according to the invention for operating a wind turbine; and

[0017] **FIG. 3**. a block diagram of the main components in the control and regulation arrangement.

[0018] A wind turbine **2**, shown in simplified form in **FIG. 1**, comprising a rotor **4** is connected to an electric grid **6** that may be a public grid, for example. Several electrical loads **8** are connected to the grid. The electrical generator of wind turbine **2**, not shown in **FIG. 1**, is coupled to an electrical control and regulation arrangement **10** that firstly rectifies the alternating current generated in the generator and subsequently converts the current into an alternating current with a frequency corresponding to the grid frequency. Instead of a grid **6**, a single load could also be supplied with electrical energy by the wind turbine **2**. The control and regulation arrangement **10** has a regulating device according to the invention.

[0019] **FIG. 2** illustrates the regulating device according to the invention. The rotor **4**, shown in simplified form, is coupled to a generator **12** that provides an amount of electrical power that depends on the wind speed and hence on the wind power. The alternating current produced in the generator **12** is initially rectified and subsequently converted into an alternating current that has a frequency corresponding to the grid frequency.

[0020] With the help of a current sensor (not shown), the amount of current being fed into the grid **6** (**FIG. 1**) is detected. Said current is compared at the same time with a predefined value I(max).

[0021] If the current fed into the grid **6** now exceeds the predefined maximum current I(max), the power generated by the entire wind turbine (and/or its generator) is adjusted by the regulating device in such a way that the current delivered to the grid does not exceed the predefined threshold value I(max). In the event of a short circuit, said current regulation can be accomplished, for example, by the wind turbine delivering a significantly lower level of power output to the grid than previously, while using elsewhere outside the grid the power that consequently is not fed to the grid, for example for a dumpload (resistance), or by feeding the power which is not fed to the grid to capacitors or other interim storage devices. As soon as full availability of the grid is restored, delivery of the stored energy to the grid can be resumed.

[0022] In this way, even when there is a short circuit in the grid, the wind turbine can continue to deliver power to the grid and support the grid without the current exceeding the predefined threshold value as a result of the short circuit.

[0023] **FIG. 3** shows constituent parts of the control and regulation arrangement **10** in **FIG. 1**. The control and regulation arrangement **10** includes a rectifier **16**, in which the alternating current produced by the generator is rectified. An inverter **18** connected to the rectifier **16** converts the direct current back into an alternating current with a frequency corresponding to the grid frequency. This current is fed into the grid **6** in three phases **L1**, **L2** and **L3**. The inverter **18** is controlled with the help of a microcontroller **20** that forms part of the regulating device. The microprocessor **20** is coupled for this purpose to the inverter **18**. The input variables for regulating the current with which the electrical power provided by the wind turbine **2** is fed into the grid **6** are the momentary current and/or the momentary currents, the grid frequency, the electrical power output P of the generator, the power factor cos ϕ and the power gradient dP/dt. Regulation, pursuant to the invention, of the current to be delivered to the grid is implemented in microprocessor **20**. The current in each of phases **L1**, **L2** and **L3** is separately detected and the respective levels are taken into account in the regulation arrangement pursuant to the invention.

[0024] If the measured current (level) I(actual) of a phase rises above a predetermined maximum current, the inverter **18** is controlled in such a way that the current (level) falls below the predefined maximum current I(max), with the electrical energy generated from wind energy and not delivered to the grid being used elsewhere, for example by being outputted to a resistance (dumpload) or stored in an interim storage device (e.g. a capacitor or Ultracap).

[0025] The control system for the wind turbine can operate independently. The wind turbine then detects a short circuit in the grid, for example by monitoring the voltages of the separate grid phases and/or their phase position. If predefinable threshold values for voltages and/or phase differences are reached, the wind turbine recognizes a short circuit and operates according to an algorithm provided for such a case.

[0026] Owing to the external access **(22)**, it is possible, for example for the power supply company to whose grid the wind turbine is connected, to intervene in the operation of the wind turbine and, for example, to modify the amount of current to be delivered to the grid, the type of current (active current, reactive current) and/or the phase angle and/or phase position, etc. In this way, the power supply company can adjust precisely those values (current, voltage, electrical power) in respect of the power to be delivered to the grid by the wind turbine that correspond to the requirements of the network operator.

1. Method for operating a wind turbine with an electrical generator, drivable by a rotor, for supplying electrical power to an electrical load, in particular an electric grid, characterized in that the power delivered by the generator **(12)** to the load **(6)** is regulated in response to a current that is outputted to the load **(6)**.

2. Method according to claim 1,

characterized in that the power outputted by the generator **(12)** to the load is regulated in response to the amount of current outputted to the load.

3. Method according to claim 1 or **2**,

characterized in that the current is an alternating current with a predefinable frequency.

4. Method according to claim 3,

characterized in that the predefinable frequency is substantially equal to the grid frequency.

5. Method according to one of the preceding claims,

characterized in that the outputted power does not exceed a predefinable amount, has a predefinable phase position and/or includes a predefinable proportion of reactive current.

6. Method according to claim 5,

characterized in that, in multiphase systems, the amount, phase position and/or the proportion of reactive current for each phase do not exceed the predefinable value.

7. Method according to claim 5 or **6**,

characterized in that for each phase a value independent of the other phases can be predefined.

8. Method according to one of the preceding claims, characterized in that the current is limited for every phase affected by a short circuit to the momentary value at the moment the short circuit occurs.

9. Wind turbine, in particular for implementing a method according to the preceding claims, comprising a rotor and an electrical generator coupled to the rotor for outputting electrical power to an electric grid, characterized by a regulating device with a current sensor for sensing the electrical current outputted to a grid **(6)**, such that the power delivered by the generator to the grid **(6)** can be regulated in response to the current that is received by the current sensor.

10. Wind turbine according to claim 9,

characterized in that the regulation device has a microprocessor **(20)**.

11. Wind turbine according to one of claims **9** or **10**,

characterized by an external control input **(22)** for transferring data to the regulating device.

12. Wind turbine according to one of the claims 9 to 11,

characterized by a device for detecting a short circuit in the grid.

13. Wind turbine according to claim 12,

characterized by a voltage sensing device for detecting the voltage of at least one phase in the grid.

14. Wind turbine according to claim 12 or **13**,

characterized by a phase monitor for detecting the phase position of the currents and/or voltages of at least one phase in the grid.

15. Wind turbine, in particular with one of the features according to one of the preceding claims, with a generator for supplying electrical power to an electric grid, characterized in that the wind turbine remains connected to the grid when a short circuit or similar disruption occurs, for example when the voltage reaches a value that deviates by more than 20% and preferably by more than 40% from the reference value.

16. Wind turbine, in particular according to one of the preceding claims, with a generator for supplying electrical power to an electric grid, and an external control input with transfer of data to a device for regulating the wind turbine, wherein control signals are received via the external control input from the grid operator or from the energy supplier operating the grid, and in response to said control signals from the grid operator the wind turbine is controlled in response to the needs of the grid operator and hence that electrical power, for example the non-reactive power, the wind power, the current position, the voltage position or the phase position, is fed into the grid in a form as required by the grid operator.

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